

A RUST BASED, ECS PATTERNED, INTERACTIVE FLIGHT SIMULATOR

THESIS

Chad A. Willis, 2d Lt, USAF

AFIT-ENG-MS-21-M-XXX

DEPARTMENT OF THE AIR FORCE

AIR UNIVERSITY

###### AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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A RUST BASED, ECS PATTERNED, INTERATIVE FLIGHT SIMULATOR

THESIS

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In Partial Fulfillment of the Requirements for the

Degree of Master of Science in xxxxx

Chad A. Willis, BS

2d Lt, USAF

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A Rust based, ecs patterned, interactive flight simulator

THESIS

Chad A. Willis, BS

2d Lt, USAF

Committee Membership:

Dr. Douglas D. Hodson, PhD

Chair

Maj. Richard A. Dill, PhD

Member

Dr. Scott L. Nykl, PhD

Member

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# Abstract

**Acknowledgments**

stuff

Chad A. Willis

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A RUST BASED, ECS PATTERNED, INTERACTIVE FLIGHT SIMULATOR

# I. Introduction

## General Issue

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## Problem Statement

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## Research Objectives/Questions/Hypotheses

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## Research Focus

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## Investigative Questions

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## Methodology

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## Assumptions/Limitations

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## Implications

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## Preview

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# II. Background

## 2.1 Chapter Overview

This chapter will give an overview of the necessary information to follow this thesis. This overview will provide the fundamentals of the Rust programming language. With that, basic networking, specifically with Rust, will be explained. Next, the Entity Component System (ECS) architecture, and an implementation of it, Specs, will be described. Furthermore, the physics for flight dynamics modeling will be laid out. Finally, the use of the FlightGear flight simulator will be explained.

## 2.2 Rust

Rust is a programming language that was designed for safety and speed. Rust can guarantee that a program will be memory safe, with no invalid data accesses, all while remaining just as fast as other popular programming languages. The C++ programming languages gives developers complete access to data inside memory, although it gives no safety precautions. The python programming language gives developers complete memory safety, but developers lose control of data inside memory. Rust combines the strengths of both C++, and Python. It guarantees memory safety and allows complete access to that memory – with exceptional performance.  
 The safety assurance of Rust is accomplished by its system of ownership and borrowing. All languages have a way to manage memory while a program is running. Some languages, like java, have a garbage collector, which actively checks for memory that is no longer being used during runtime. Other languages, like C++, make the programmer manually allocate and free memory. Rust does not take the approach of either Java or C++; it instead has a borrow-checker. At compile time, the Rust borrow checker will check that all accessed to data is legal.

Ownership is defined as a set of three rules that the programmer must follow: every value has a variable which is called its owner, there may be only one owner at a time, and values are dropped when an owner goes out of scope. Ownership takes care of dangling references, where references to data have become invalid during runtime. Ownership takes care of data races, where behavior of a program at run time will change due to external factors. Ownership takes care of buffer overflows, where out of bound data is trying to be accessed.

….With no safety concerns, “fearless concurrency” is given to the programmer because there is no worry of errors in parallel programming. The safety benefits of rust also come with no runtime cost.

Performance, concurrency, memory efficiency. Rust is a fast programming language – matches r even exceeds speeds of its peers. “fearless concurrency” parallel programming is free of errors that other languages have which makes concurrency be seen as difficult. “zero cost abstraction” features gained from rust have no runtime cost, safety does not mean a slower program speed. Downsides include longer compile time, compiler is strict, large language [1]. Compiler is like a safety net. The type system is smart enough to find all the urn time bugs. More time to compile, but once it does, its most likely right. Use rust for correctness. Good type system. Can be sure code is correct at compile time. Rust has no garbage collector, the compiler is the garbage collector. Ownership replaces the need for a garbage collector and assures memory safety. Borrowing references avoids data races with two pointers accessing the same memeory at the same time. This is good for performance, and less memory overhead. Community is excellent, ecosystem. Mozilla has been the driving factor behind rust. Used in firefox. Ecosystem is quickly growing, providing libraries, called crates in rust. Rust model pushes you to design your programs differently than OOP. Programs Less about execution flow and what the cpu is doing and more about how data is laid out in memory. And how data is laid out in memory . and how ownership of memory is given to different parts of the program at run time. Spend more time getting the compiler right and less time fixing bugs.

Ownership, borrowing (references), lifetimes = memory safety. There is exactly one binding to any given resource. When ownership of memory is transferred to another binding, the original binding cannot be used. Only one reference can own a piece of data at a time. References allow borrowing a piece of data for a moment [2].

Clear up these thoughts on ownership   
  
Traits…Error Handling…

## 2.3 Rust and Networking

Networking can simply be defined as two programs communicating with each other, sending and receiving data. To do this, two sockets are required at each end of communication. In this case, the type of socket being used is the Datagram socket. The protocol involving Datagram sockets is called the User Datagram Protocol (UDP). This protocol is considered “connectionless” because an open connection does not need to be maintained. Packets containing bytes of data may simply be built and sent to a destination without a connection needing to be established prior [3].

In Rust, a UdpSocket can be created and binded to an ip address and port on the local machine. After this, data can be sent and received from any other socket address. The socket created can then be connected to the other socket with its ip address and port. From here, data can be sent using the send function, and data can be received using the recv function. (code example from rust-lang)

A machines computer architecture represents bytes in a specific order. There are two byte orderings: most significant byte comes first in the ordering, and least significant byte first comes in the ordering. Most significant byte first is called Network Byte order, and least significant byte first is called Host Byte Order. When sending and receiving data, one must be aware of the order on either machine which is necessary to interpret the bytes correctly. So the order may need to be converted first before packets of data are sent from one socket to another [3].

## 2.4 Entity Component System

Networking can simply be defined as two programs communicating with each other, sending and receiving data. To do this, two sockets are required at each end of communication. In this case, the type of socket being used is the Datagram socket. The protocol involving Datagram sockets is called the User Datagram Protocol (UDP). This protocol is considered “connectionless” because an open connection does not need to be maintained. Packets containing bytes of data may simply be built and sent to a destination without a connection needing to be established prior [3].

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## 2.5 Physics of Flight Modeling

## 2.6 FlightGear

FlightGear is an open-source flight simulator application. In the beginning stage of this thesis, FlightGear was leveraged as a visual system. It was used to receive network UDP packets and display the result on the simulation.

1 Rust in action book  
2 <https://doc.rust-lang.org/1.9.0/book/>  
3 Beej’s Guide to Network Programming **-** Using Internet Sockets  
4. ECS game engine design

<http://t-machine.org/index.php/2007/09/03/entity-systems-are-the-future-of-mmog-development-part-1/>

<http://entity-systems.wikidot.com/>

<https://blog.gds-gov.tech/appreciating-rust-memory-safety-438301fee097>

Text

# III. Methodology

## Chapter Overview

The purpose of this chapter is

## Test Subjects

Text

## Summary

Text

# IV. Analysis and Results

## Chapter Overview

Text

## Results of Simulation Scenarios

Text

number Equation

Where:

X *bar* = population mean of sorties produced by squadron (LCOM)

μo = Actual number of sorties produced (Actual FY2002)

S = Standard deviation of the population mean of sorties produced (LCOM)

n = 75 replications

## Investigative Questions Answered

Text

## Summary

Text

# V. Conclusions and Recommendations

## Chapter Overview

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## Conclusions of Research

Text

## Significance of Research

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## Recommendations for Action

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## Recommendations for Future Research

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## Summary

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# Appendix

# Bibliography

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# Vita

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